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UNCONSOLIDATED AQUIFERS IN TOMPKINS COUNTY, NEW YORK

By Todd S. Miller

INTRODUCTION

Unconsolidated aquifers consisting of saturated sand and gravel are capable of supplying large quantities of good-quality water to wells in Tompkins County, but little published geohydrologic information on such aquifers is available. In 1986, the U.S.Geological Survey (USGS) began collecting geohydrologic information and well data to construct an aquifer map showing the extent of unconsolidated aquifers in Tompkins county. Data sources included (1) water-well drillers' logs; (2) highway and other construction test-boring logs; (3) well data gathered by the Tompkins County Department of Health, (4) test-well logs from geohydrologic consultants that conducted projects for site-specific studies, and (5) well data that had been collected during past investigations by the USGS and entered into the National Water Information System (NWIS) database. In 1999, the USGS, in cooperation with the Tompkins County Department of Planning, compiled these data to construct this map.

More than 600 well records were entered into the NWIS database in 1999 to supplement the 350 well records already in the database; this provided a total of 950 well records. The data were digitized and imported into a geographic information system (GIS) coverage so that well locations could be plotted on a map, and well data could be tabulated in a digital data base through ARC/INFO[1] software. Data on the surficial geology were used with geohydrologic data from well records and previous studies to delineate the extent of aquifers on this map.

This map depicts (1) the extent of unconsolidated aquifers in Tompkins County, and (2) locations of wells whose records were entered into the USGS NWIS database and made into a GIS digital coverage. The hydrologic information presented here is generalized and is not intended for detailed site evaluations. Precise locations of geohydrologic-unit boundaries, and a description of the hydrologic conditions within the units, would require additional detailed, site-specific information.

GEOLOGIC SETTING

Tompkins County is within the glaciated Allegheny Plateau physiographic province (fig. 1). The bedrock that forms the part of the Allegheny Plateau that lies within Tompkins County consists of sedimentary rocks of marine origin–mostly Devonian shale, siltstone, fine-grained sandstone, and some limestone (fig. 2). The regional dip of the strata is to the south-southwest at 10 to 40 ft/mi, but superimposed on the regional trend are mild structural deformities such as large, gentle folds and a few small thrust faults (Karig and Elkins, 1986).

Effects of Glacial Erosion

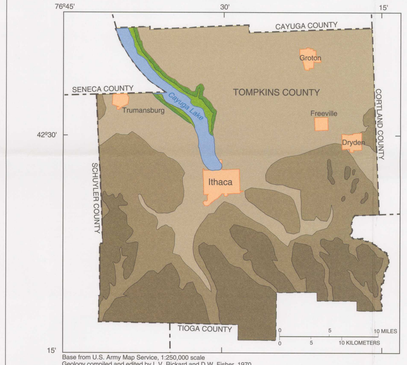
Millions of years of fluvial erosion of the Allegheny Plateau during the Tertiary Period (1.6 to 66 million years before present), followed by several episodes of glacial erosion and deposition during the Pleistocene Epoch (0.01 to 1.6 million years ago), have extensively modified the landforms in upstate New York. Ice sheets intermittently covered the northeastern United States, including Tompkins County, between 1.6 million and 10,000 years before present. The last of these ice sheets (Late Wisconsinan) covered the area between 23,000 and 10,000 years before present (Fullerton, 1980). Scouring by the ice modified the bedrock topography and eroded most of the previously deposited unconsolidated materials (Muller and others, 1988); thus, sediments that are most prevalent are those that were deposited during the last glaciation.

A major readvance of ice, called the Valley Heads readvance, about 13,000-14,000 years before present (Fullerton, 1980) paused in river valleys in central and western New York at bedrock ridges that formed the preglacial drainage divide between the Susquehanna River basin and the Lake Ontario basin. The breeching of this divide by previous glacial erosion had formed "saddles", or broad valleys with small headwater drainages, that are called "through valleys." Later the reccession of the Valley Heads ice left a large moraine (thick deposits of glacial drift) in many of the through valleys. In Tompkins County, this moraine forms the drainage divide between the southward draining Susquehanna River basin and the northward draining Cayuga Lake basin and is known as the "Valley Heads Moraine." (See inset, fig. 1.) The through valleys slope gently southward from the divide into the Susquehanna River basin, and more steeply northward. These through valleys are drained only by small headwater streams; otherwise they resemble major river valleys in that they are wide and flat and partly filled with a few hundred feet of glacial deposits, including some saturated sand and gravel.

The northern part of the county (fig. 2) has undergone severe glacial erosion, which deepened the Cayuga Lake trough more than 1,000 ft (Mullins and others, 1991), smoothed its sides, and wore away the lower reaches of lateral tributary valleys that led to the trough. Glacial erosion also smoothed and lowered by several hundred feet the moderately rugged hills that once formed the uplands (Coates, 1974) and extensively eroded many of the small upland valleys, many to the point of obliteration. Present-day topography in the northern part of the county is dominated by the deep, smooth-sided Cayuga Lake trough, surrounded by relatively low, gently rolling hills (relief ranging from 200 to 400 ft), and many poorly defined valleys in the uplands.

Glacial erosion deepened the Cayuga Lake trough as much as 1,000 ft more than the lateral tributary valleys. This deepening of the trough left the tributary valleys several hundred feet higher than the present-day lake level and more than 1,000 ft above the bedrock floor of the trough. Valleys whose floors are higher than the floor of the valley to which they lead are called "hanging valleys". The streams that flow in hanging valleys originate in glacial-drift-filled valleys in the uplands; where these streams exit the drift-filled valley along the Cayuga Lake trough, they cascade through steep bedrock ravines and gorges before flowing into Cayuga Lake. The largest hanging valleys in the county include the Taughannock Creek, Salmon Creek, Fall Creek, and Enfield Creek valleys. Several deep wells drilled along the flanks of the trough do not reach bedrock; this indicates that there are buried interglacial gorges near some of the present-day gorges, but neither the boundaries nor the extent of these gorges are known.

The southern part of Tompkins County was less severely eroded than the northern part. The southern part is in the dissected Appalachian Plateau (fig. 1), where glacial deepening of valleys and lowering of the uplands (about 200 ft) was less extensive than in the northern part of the county (Coates, 1974). The southern part contains moderately to steeply sloping hills and a greater density of sizable valleys than the northern part. Relief in the southern part typically ranges from 600 to 800 ft.



EXPLANATION

- WEST FALLS GROUP– Shale and sandstone
- SONYEA GROUP– Shale
- GENESEE GROUP– Shale and siltstone
- TULLY LIMESTONE FORMATION
- HAMILTON GROUP– Shale, siltstone, and thin limestone beds

Figure 2. Generalized geologic map of Tompkins County, New York

EXPLANATION

AQUIFERS

Unconfined

ALLUVIAL – Sand and gravel with some silt deposited at mouths of tributary streams along sides of large valleys; typically 10 to 40 feet thick; receives recharge primarily from the fan-building tributaries that typically lose water by infiltration through the streambed to the underlying water table. Alluvial fans that overlie unconfined aquifers generally form a locally thick unconfined aquifer at that location. Alluvial fans that overlie fine-grained valley-fill deposits (confining units) that, in turn, overlie a confined aquifer, represent a system of two or more aquifers (unconfined aquifer underlain by confined aquifer[s]).

DELTA – Sand and gravel deposited at the shore of Cayuga Lake and shores of former proglacial lakes; typically 10 to 50 feet thick. Many of the high-elevation deltas (called hanging deltas) are unsaturated most of the year.

OUTWASH – Coarse sand and gravel deposited predominantly in valleys by glacial meltwaters; typically 20 to 80 feet thick; Outwash aquifers typically can yield large amounts of water (more than 100 gallons per minute) to screened wells.

KAME DEPOSITS – Coarse sand to cobble gravel with some sand lenses initially deposited on or adjacent to the glacier and later collapsed on the ground as the ice melted; typically 20 to 100 feet thick; includes kame terraces, kame deltas, kame moraines, and eskers; variable sorting. May be seasonally saturated where kames are along hillsides.

Unconfined and Confined

SURFICIAL AND BURIED SAND AND GRAVEL – Surficial sand and gravel that overlies fine-grained confining units that, in turn, overlie sand and gravel. These areas contain multiple aquifers.The hydraulic connection among aquifer units were not investigated during this study.

MORAINE – Predominantly the Valley Heads Moraine in Tompkins County. Heterogeneous mix of till; lacustrine clay, silt and fine sand; and water-yielding sand and gravel; complex stratigraphy (deposits commonly reworked and disturbed by ice) makes geohydrologic conditions in any one place difficult to predict. In places, the moraine may contain an unconfined aquifer, a confined aquifer, unconfined and confined aquifers, or multiple confined aquifers.

Confined

UNDIFFERENTIATED SAND AND GRAVEL – Sand and gravel of unknown origin, overlain by fine-grained deposits such as till and (or) lacustrine fine sand, silt and clay. Extensive confined aquifers are commonly found overlying bedrock in many valeys; less-extensive confined aquifers are scattered at various depths with the valley-fill deposits at some locations.

Unknown

PRESENCE OF AQUIFERS IS UNKNOWN – Areas of valley-fill deposits in which data were insufficient to determine whether a significant aquifer was present.

Till and Bedrock

TILL AND BEDROCK – Till consists of a poorly sorted mixture of clay, silt, sand, and stones that were compacted by the ice. Till yields water to wells extremely slowly and, therefore, does not form a significant aquifer. Devonian sedimentary rocks; mostly shale, siltstone, fine-grained sandstone, with some limestone; bedrock units have little primary openings; therefore, water is available mostly from fractures; limestone units such as the Tully Limestone have some solution-widened joints that result in greater water-yielding properties than other bedrock units.

AQUIFER BOUNDARY

WELL AND WELL NUMBER – Includes all wells except municipal wells. Well numbers correspond to those wells and test borings in the U.S. Geological Survey computer database (Ground Water Site Inventory). The wells and test borings are numbered sequentially within the county by the U.S. Geological Survey.

COMMUNITY WATER-SUPPLY WELL AND WELL NUMBER – Well numbers correspond to those wells in the U.S. Geological Survey computer database (Ground Water Site Inventory). The wells are numbered sequentially within the county by the U.S. Geological Survey.

Deposition of Unconsolidated Deposits

As the last glacier to occupy Central New York moved southward, it eroded rock and fine-grained sediment, which became entrained in the ice or was dragged and ground up along its bottom. This material was eventually deposited as till on top of bedrock. The till in the study area is a poorly sorted mixture of clay, silt, sand, and stones that were compacted by the ice. Till is commonly referred to by drillers and farmers as "hardpan" or "boulder clay." Till predominates in the uplands, but in the valleys it is interspersed and/or typically overlain by alluvium, glaciofluvial deposits, and glaciolacustrine deposits. Till yields water to wells extremely slowly and, therefore, does not form a significant aquifer; as a result, the wells of most homeowners in the uplands are drilled into bedrock.

The thickness of unconsolidated deposits in the uplands (mostly till) ranges from zero to more than 150 ft. Upland areas in which till is absent (bedrock is exposed at land surface) include: (1) the tops of hills, especially the highest ones, (2) oversteepened valley walls that were severely eroded by the glacier, (3) some stream channels, and (4) some north-facing slopes, especially on the highest parts. The thickest till deposits (typically from 50 ft to as much as 150 ft thick) are on the south-facing hillsides.

AQUIFERS

Aquifers are water-bearing geologic formations that can transmit enough water to wells at a useful rate. They can consist of unconsolidated sediment or of bedrock. Aquifers that can provide the largest amounts of water to wells consist of sand and gravel and are present mostly in large river valleys. Sand and gravel aquifers can typically yield from 5 to several tens of gallons per minute (gal/min) to wells finished with open-ended-casings and can yield from several tens to more than 100 gal/min to screened wells.

Unconfined Aquifers

Unconfined aquifers are those in which the water table is exposed to the atmosphere through openings (pore spaces) in the overlying material. Unconfined aquifers are recharged by precipitation that percolates directly to the water table and by water from upland sources such as (1) runoff that seeps from adjacent unchanneled hillsides into the aquifer along its edges, and (2) seepage from tributary streams that flow from till-and-bedrock upland basins and onto the aquifer surface in the valley. Unconfined aquifers are highly susceptible to contamination from human activities because chemicals applied to, or leaked onto, land can readily migrate downward to the water table. Unconfined aquifers in Tompkins County typically consist of three types–recent alluvium, deltaic deposits, and outwash deposits.

Alluvial-Fan and Deltaic Aquifers

Alluvial-fan aquifers formed where tributaries deposited coarse-grained sediment (mostly sand and gravel with some silt) where they entered large valleys, and deltaic aquifers formed where streams deposited their sediment where they entered a lake, (such as Cayuga Lake or former proglacial lakes). Deposition of alluvial-fan aquifers over unconfined aquifers increased the thickness of the unconfined aquifer at that location; whereas deposition of alluvium over fine-grained valley-fill deposits (confining units) that overlie a confined aquifer represent a two-aquifer system–a surficial aquifer separated from a lower confined aquifer by a confining unit.

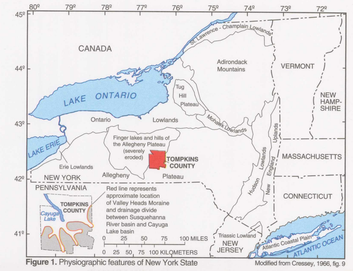


Figure 1. Physiographic features of New York State

Modified from Cressey, 1966, fig. 9

Complex Aquifer Settings

The deposits that form the Valley heads moraine consist of heterogeneous sediments and a complex stratigraphy that make the geohydrologic conditions at a particular place difficult to predict. For example, the Valley Heads Moraine in the Dryden Lake-Harford through valley consists of many thin, discontinuous layers of till, fine-grained lacustrine deposits, and confined coarse sand and gravel aquifers; the latter form at least five confined water-bearing zones (Miller, 1993). The general aquifer characteristics of four through valleys in Tompkins County (Pony Hollow, Willseyville Creek, Caroline, and Dryden-Harford valleys) are described by Randall and others (1988); Randall did not investigate the through valley at the headwaters of Cayuga Inlet valley.

Bedrock Aquifers

Bedrock in Tompkins County consist mostly of Devonian shale, siltstone, fine-grained sandstone, and some limestone (fig. 2). These rocks generally provide sufficient quantities of water to supply households and most small farms throughout the county, but the yield is smaller and the water quality inferior to sand-and-gravel aquifers. The rock units in Tompkins County have little primary porosity (pore spaces between grains of the rock matrix); therefore, most of the water in the bedrock aquifers is derived from secondary porosity, such as fractures and bedding-plane openings; these openings in the shale, siltstone, and sandstone units typically are extermly thin and, therefore, can store and transmit only relatively small amounts of water to wells (typically yields from less than 1 gal/min to 10 gal/min). The Tully Limestone, a carbonate unit, may be the only bedrock unit that can consistently yield relatively large amounts of water (several tens of gallons per minute) to wells. This unit consists of slightly soluble calcite and dolomite in which some of the openings along joints and bedding planes have been enlarged through dissolution, especially where the unit is less than 200 ft deep, where the circulation of freshwater is adequate to dissolve limestone. Water at greater depths in this unit (more than 200 ft below land surface) has been in contact with the rock matrix for a relatively long time and has dissolved a relatively high concentration of minerals than water at shallower depths and, therefore, is less able to dissolve additional minerals. The Tully Limestone generally yields larger amounts of water to wells than noncarbonate bedrock units but less than sand and gravel aquifers.

Outwash Aquifers

Meltwater from glaciers in southward draining valleys flowed away from the ice front as braided streams and deposited large amounts of outwash (coarse sand and gravel) on top of older glacial deposits within these valleys. Outwash aquifers are typically high yielding. Deposition of outwash over older, fine-grained lacustrine deposits (lake-bed sediments) that are, in turns, underlain by an older, confined sand and gravel aquifer, resulted in a two-aquifer system. Outwash aquifers in Tompkins County are of limited extent and are found only along short reaches in valleys near the southern edge of the county.

Confined Aquifers

A confined aquifer is a buried geologic deposit that has moderate to high permeability and is overlain by a geologic unit having low permeability, such as silt and clay, that restricts the movement of ground water into (or out of) the aquifer that underlie it. Most of the large valleys in Tompkins County contain an unconfined aquifer, a confined aquifer, or both. Confined aquifers are less susceptible than unconfined aquifers to contamination from surface sources because the confining unit impedes the downward movement of contaminants.

Some confined aquifers are overlain by only a confining unit. For example, most of the north-draining valleys north of the Valley Heads Moraine contained proglacial lakes (lakes that formed between the ice lobe and drainage divide); thus, the sand and gravel deposits in the valley became overlain by lacustrine silt and clay deposits (Miller, 1993). Such buried aquifers have been identified at Cayuga Inlet, Fall Creek, Taughannock Creek, Virgil Creek, Sixmile Creek, and Owasco Inlet valleys. Some basal, confined sand-and-gravel aquifers that overlie bedrock are extensive, whereas confined aquifers above the basal aquifer, are less extensive and may be scattered at various depths.

REFERENCES CITED

Coates, D.R., 1974, Reappraisal of the Glaciated Appalachian Plateau, *in* Coates, D.R., ed., Glacial geomorphology–Proceedings of the Fifth Annual Geomorphology Symposia Series: Binghamton, N.Y., State University of New York at Binghamton, p. 205-243.

Cressey, G.B., 1966, Land forms, *in* Thompson, J.H., (ed.), Geography of New York State: Syracuse University Press, p. 19-53.

Fullerton, D.S., 1980, Preliminary correlation of post-Erie interstadial events (16,000-10,000 radiocarbon years before present), Central and Eastern Great Lakes Region, and Hudson, Champlain, and St. Lawrence Lowlands, United States and Canada: U.S. Geological Survey Professional Paper 1089, 52 p.

Karig, D.E. and Elkins, L. T., 1986, Geological summary of the Cayuga region, *in* New York State Geological Association Field Trip Guidebook, 58th Annual Meeting, Ithaca, N.Y., Cornell University, p. 1-21.

Miller, T.S., 1993, Glacial geology and the origin and distribution of aquifers at the Valley-Heads Moraine in the Virgil Creek and Dryden Lake-Harford valleys, Tompkins and Cortland Counties, N.Y.: U.S. Geological Survey Water-Resources Investigations Report 90-4168, 34 p.

Muller, E.H., Braun, D.D., Young, R.A., and Wilson, M.P., 1988, Morphogenesis of the Genesee Valley: Northeastern Geology, v. 10, no. 2, p. 112-133.

Mullins, H.T., Wellner, R.W., Petruccione, J.L., Hinchey, E.J., and Wanzer, Steven, 1991, Subsurface geology of the Finger Lakes Region, *in* Ebert, James, ed., Oneonta, N.Y., New York State Geological Association Field Trip Guidebook, 63rd annual meeting: p. 1-54.

Randall, A.D., Snavely, D.S., Holecek, T.J., and Waller, R.M., 1988, Alternative sources of large seasonal ground-water supplies in the headwaters of the Susquehanna River basin, New York: U.S. Geological Survey Water-Resources Investigations Report 85-4127, 121 p.

Rickard, L.V. and Fisher, D.W., 1970, Geologic map of New York State–Finger Lakes sheet: New York State Museum and Science Service, Map and Chart Series no. 15, scale 1:250,000.

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